A comparison between measurements of the F-layer critical frequency and values derived from the PRISM adjustment algorithm applied to total electron content data in the equatorial region

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Abstract:

The Parametrized Real-Time Ionosphere Specification Model (PRISM) is a global ionospheric specification model that can incorporate real-time data to compute accurate electron density profiles. Two important data types which can be ingested into PRISM are ionosonde data (critical frequencies and heights) and total electron content (TEC). The adjustment algorithm incorporates measurements of F-layer critical frequencies (foF2) directly, but the TEC data must first be converted to equivalent foF2 values. To assess the accuracy of the conversion algorithm in the equatorial region, TEC data from a global positioning system (GPS) receiver in Fortaleza, Brazil (3 .9S, 38.4W) is used to compute foF2 values above a nearby ionosonde station (Sao Luis, 2.6S, 44.3W) for comparison with measured values. Time series of computed and measured foF2 ~~will be~~ presented for several days in November 1993, using ionosonde and GPS data recorded at 15-minute and 30-second intervals, respectively. This comparison can be used to suggest methods of optimizing the PRISM adjustment algorithm for TEC data obtained at low latitudes.

PRISM Model Adjustment Algorithm in the Equatorial Region

Summary of the Figures

The figures plot modeled and measured ionospheric total electron content (TEC) and F-layer critical frequencies (*foF2*) for 3 days in November of 1993. The measurements were obtained from two nearby instruments located in Brazil: an ionosonde at Sao Luis (2.6S, 44.3 W) and a dual-frequency GPS receiver at Fortaleza (3.9S, 38.4W).

Each plot shows three quantities:

1) Measured TEC or critical frequency.

2) Predicted TEC or critical frequency based on the unadjusted PRISM model (also known as PIM)

3) Predicted TEC or critical frequency based on the PRISM model adjusted with real-time TEC data.

The measured TEC values are slant values mapped to zenith using the cosecant elevation mapping function. PRISM always produces vertical TEC values.

PRISM Model Adjustment Algorithm in the Equatorial Region

Data Processing

The measured slant TEC data were converted to an equivalent vertical value assuming an ionospheric shell height of 350 km and a simple thin-shell (cosecant) elevation mapping function. TEC data from the Fortaleza receiver were selected so that the ionospheric pierce points lay within a 4-degree radius of Sao Luis. All TEC data shown in the plots were used as input to the PRISM model. The 3-hour Kp values for the three days considered were 3.0 or below.

The 3 days analyzed in this study were ho en n e hey on a n a fairly complete record of foF2 values from the Sao Luis ono onde from No embe 993.

Discussion

The purpose of this study was to assess the PRISM algorithm for ingesting TEC data. TEC data are used to adjust the a priori electron density profiles of the model (see reference 1 for details). Comparing the measured foF2 values with those calculated from the TEC can be used to assess whether the TEC-to-foF2 conversion is valid in the equatorial region.

The TEC predicted by the PIM model (i.e. unadjusted PRISM) both over-estimates and under-estimates the actual TEC values. However, after adjustment, PRISM values accurately reproduce the TEC data for all three days studied here. This is encouraging and demonstrates internal consistency of the adjustment algorithm.

The PRISM model appears fairly successful in predicting foF2 values before adjustment. After adjustment, agreement with the data generally improves for local times exceeding 10:00. However, for all three days, the adjustment produces worse agreement in the early morning hours. The overly large foF2 during these times may reflect the fact that PIM lacks a protonospheric model. Since the the model does not contain sufficient density in the topside, the foF2 value is adjusted too high to compensate. A similar result has been observed at mid-latitudes, which has spurred development of a protonospheric model to be incorporated into PRISM [2].

References

[1] R. E. Daniell, W. G. Whartenby, L. D. Brown, Parametrized Real-Time Ionospheric Specification Model, Version 1.2, Algorithm Description, Computational Physics Inc., 240 Bear Hill Rd. #202A, Waltham, MA 02164, May 1993.

[2] D. N. Anderson, private communication 1994.

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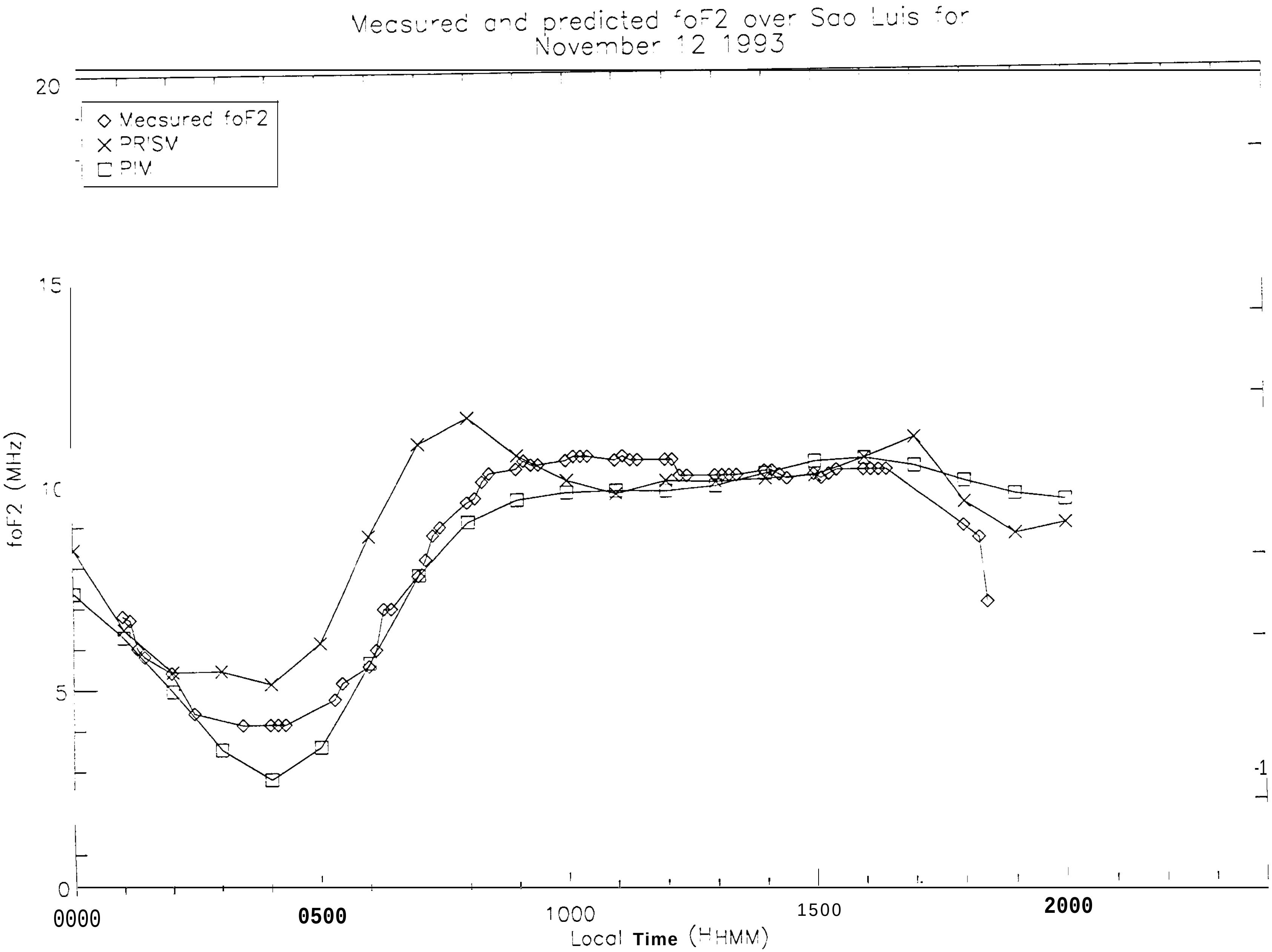
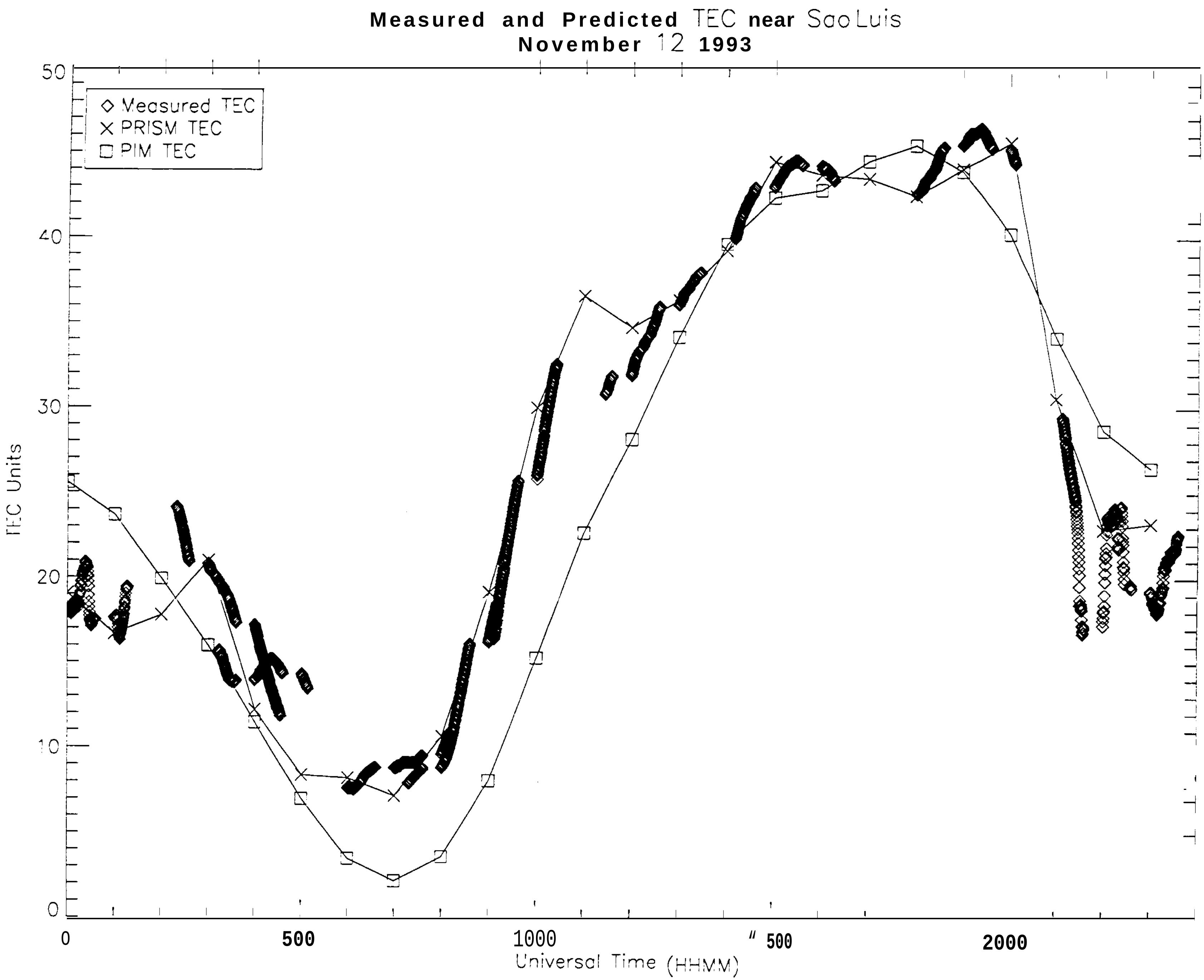
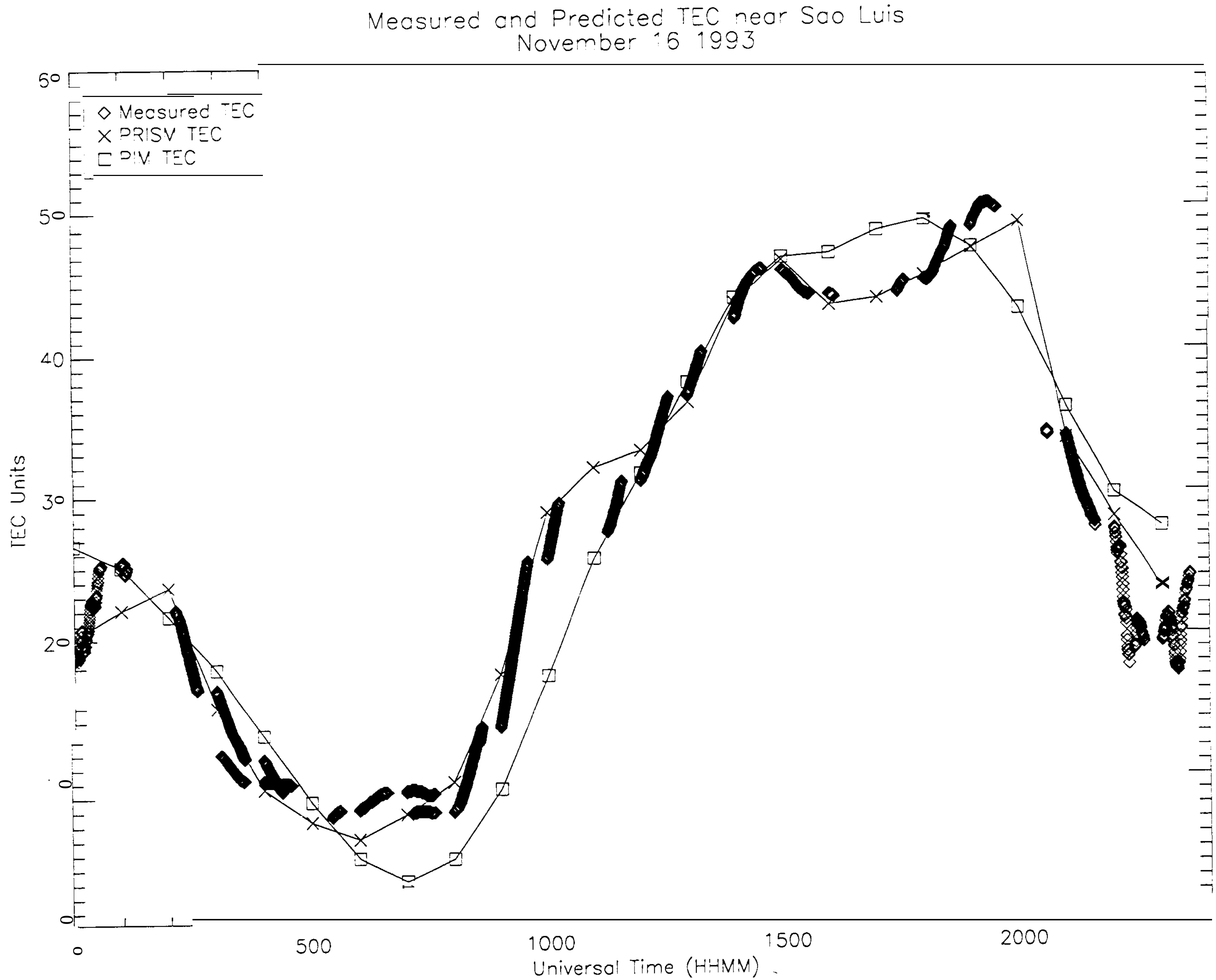
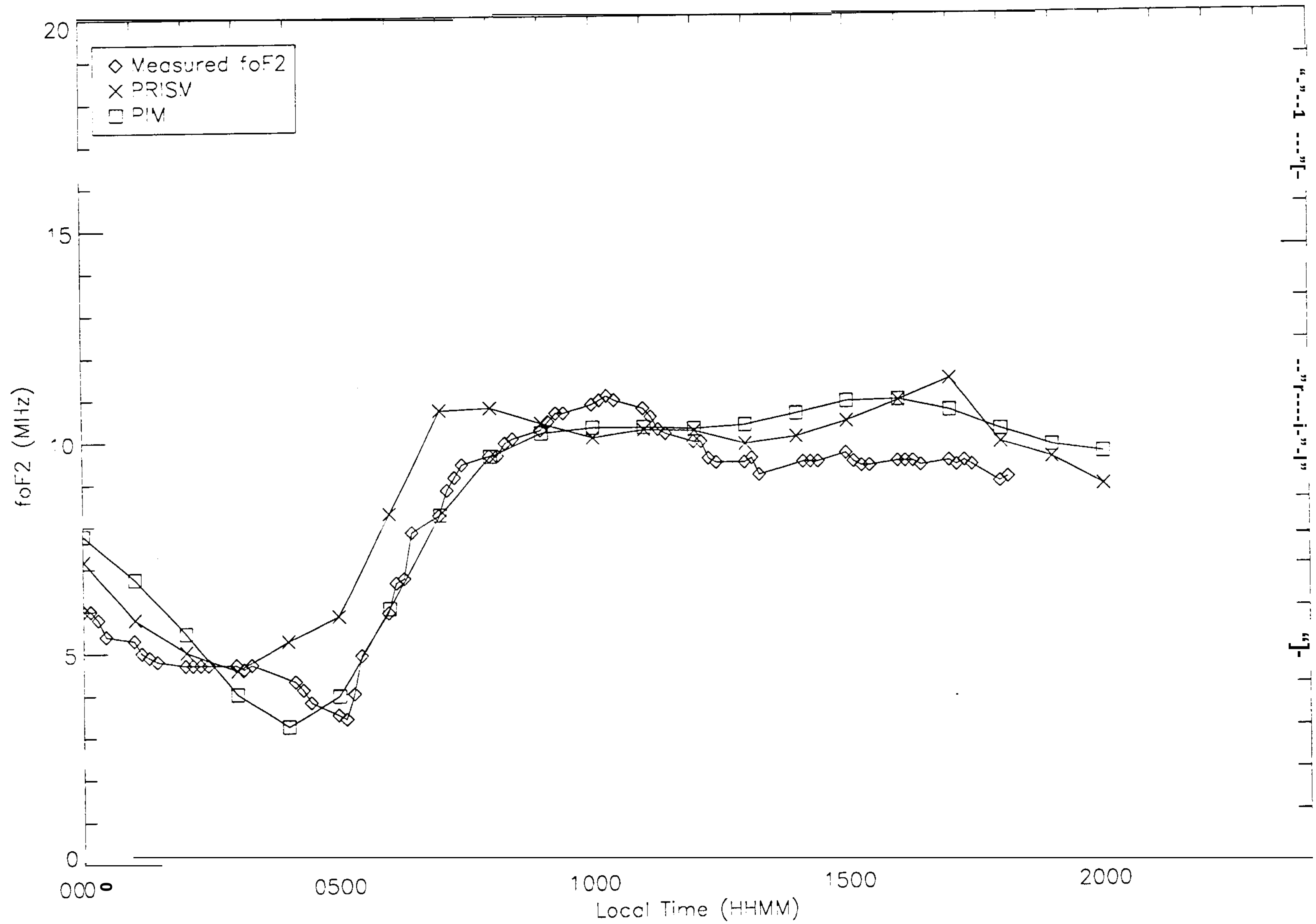


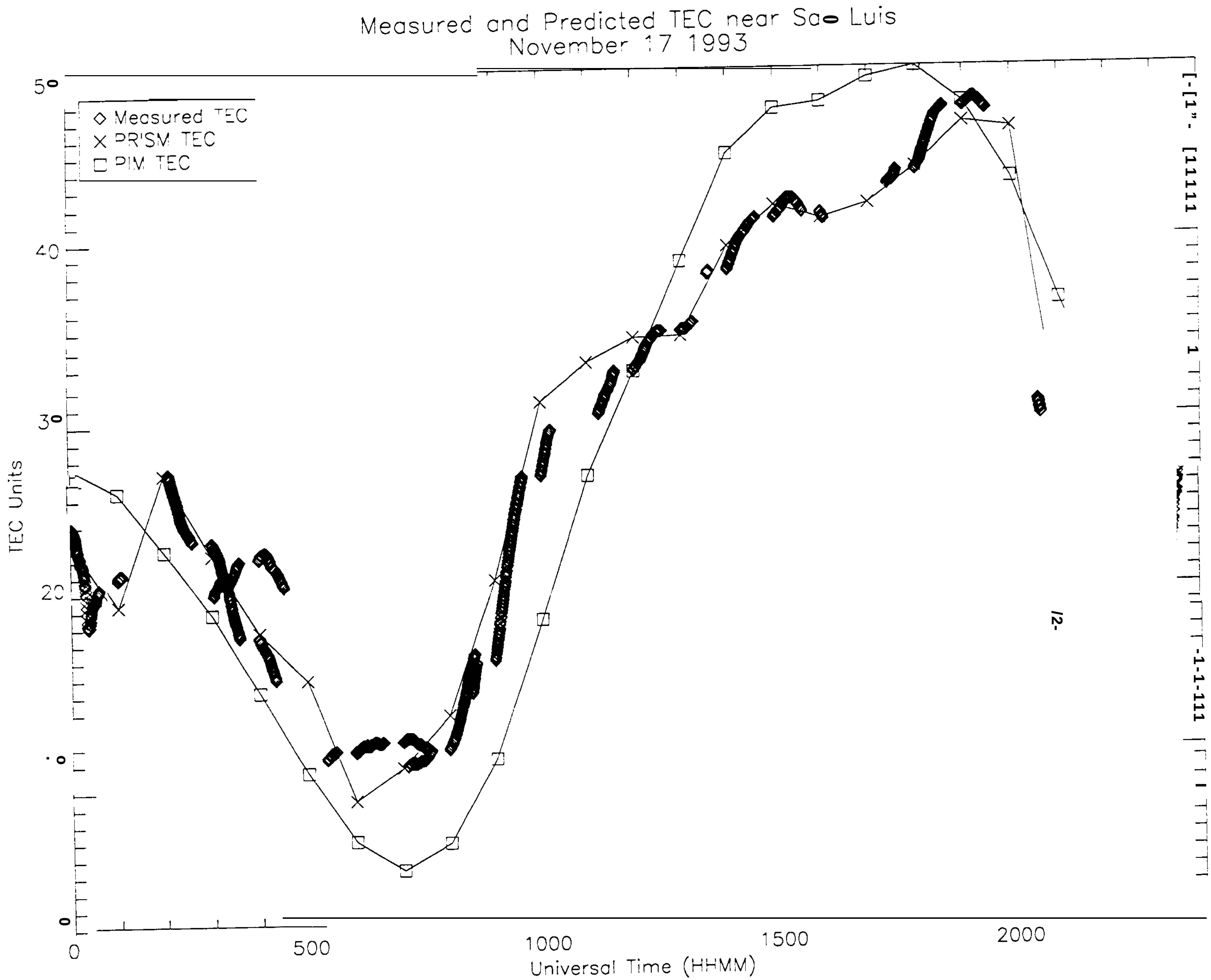
Measured and predicted foF2 over Sao Luis for
November 12 1993
Measured foF2
PRISM
PIM
foF2 (MHz)
20
15
10
5
0
0000
0500
1000
1500
2000
Local Time (HHMM)


Measured and Predicted TEC near Sao Luis
November 12 1993
Measured TEC
PRISM TEC
PIM TEC
TEC Units
Universal Time (HHMM)
0
10
20
30
40
50
500
1000
1500
2000


Measured and Predicted TEC near Sao Luis
November 16 1993
Measured TEC
PRISM TEC
PIM TEC
TEC Units
Universal Time (HHMM)
0
500
1000
1500
2000
50
40

Measured and predicted foF2 over Sao Luis for
November 16 1993





Measured and Predicted TEC near Sao Luis
November 17 1993
Measured TEC
PRISM TEC
PIM TEC
TEC Units
Universal Time (HHMM)
0
500
1000
1500
2000
50
40
30
20
0

Measured and predicted foF2 over Sao Luis for November 17 1993